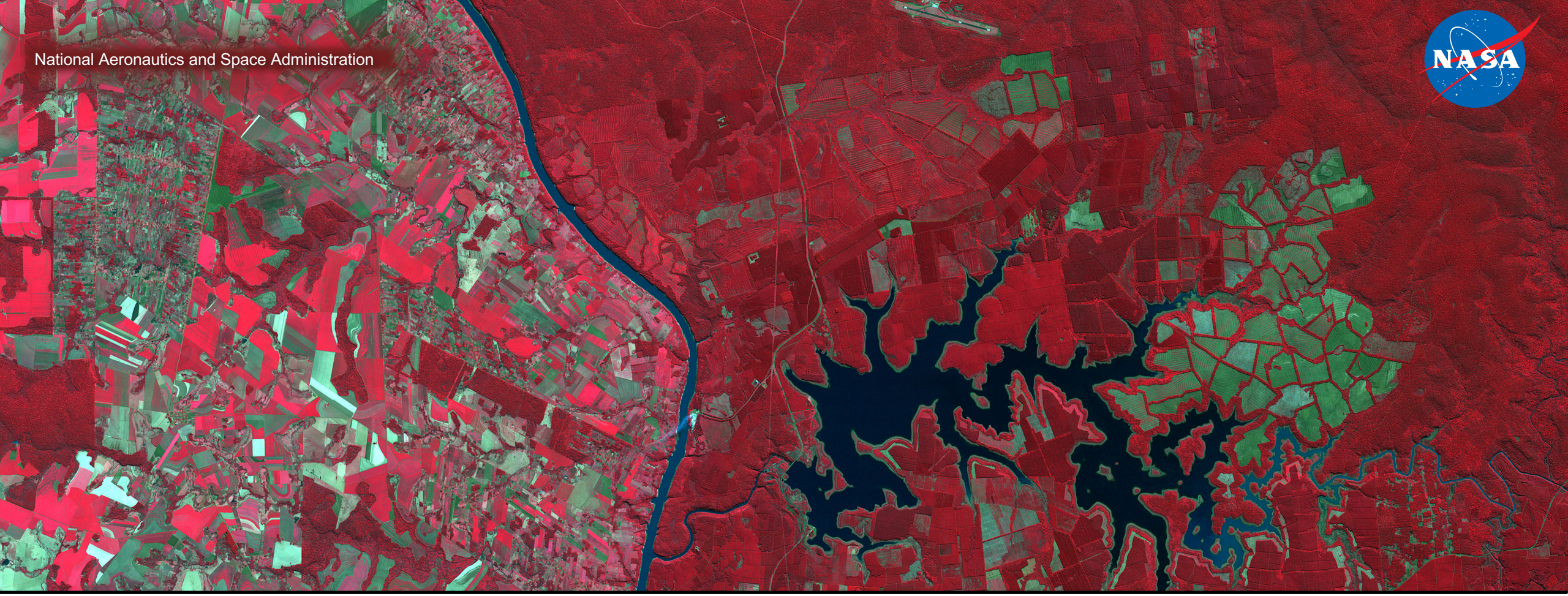

Precipitation Analysis

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December 2, 2017

Objectives

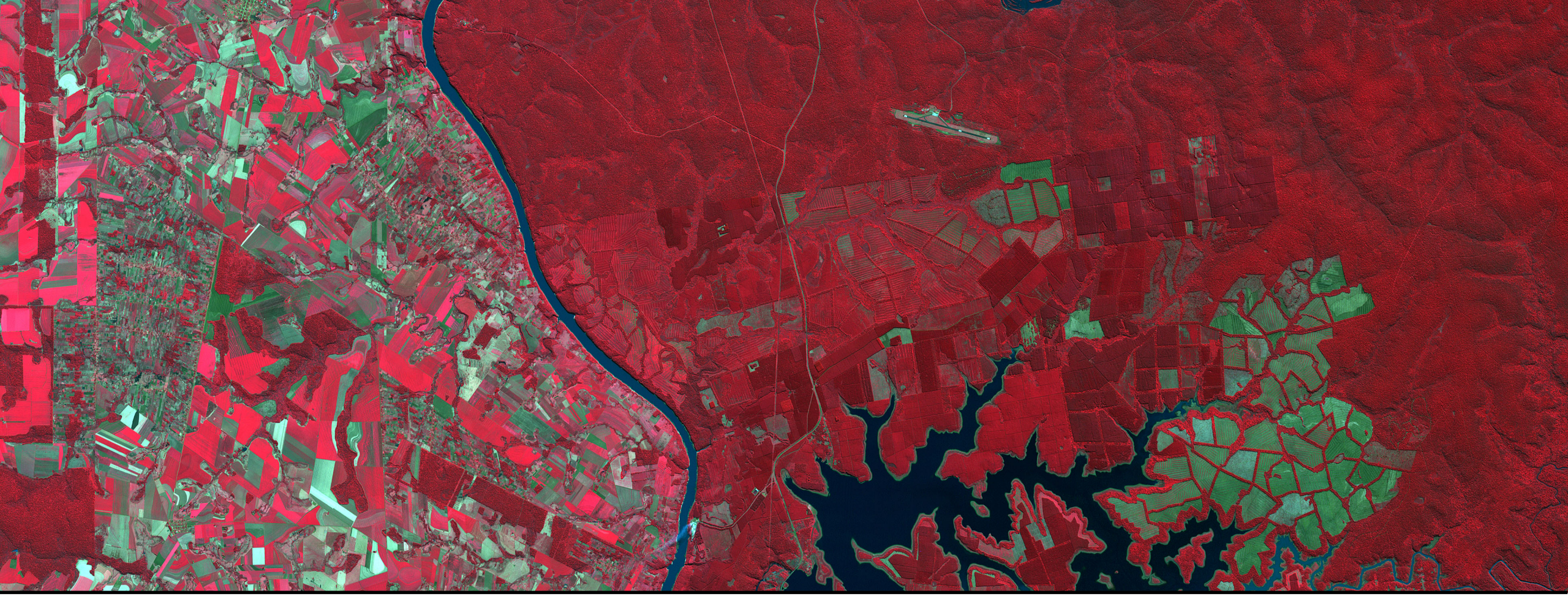
By the end of this exercise, you will be able to subset, analyze, and download precipitation data over the Parana region in southern Brazil. This exercise will use the Giovanni web tool and analyze rainfall statistics over the Sao Francisco Verdadeiro (SFV) watershed using QGIS.

Requirements

- QGIS installed on your computer
  - https://arset.gsfc.nasa.gov/sites/default/files/water/drought/Introduction%20to%20QGIS.pdf
- A shapefile for the Sao Francisco Verdadeiro (SFV) watershed saved on your computer
  - http://arset.gsfc.nasa.gov/

Outline

- Part 1: Subset Data and Make Monthly Precipitation Time Series
- Part 2: Make and Download Monthly Precipitation Maps
- Part 3: Precipitation Analysis in QGIS
  - Convert NetCDF IMERG data into GeoTIFF
  - Interpolate and Clip Precipitation Data to SFV Watershed
- Part 4: Analyze Precipitation Over SFV Watershed
  - Examine Histograms for Rainfall During December 2015 and 2016
  - Examine Mean and Standard Deviation of Rain Data Over SFV Watershed
  - Examine Inter-Annual Difference in Precipitation



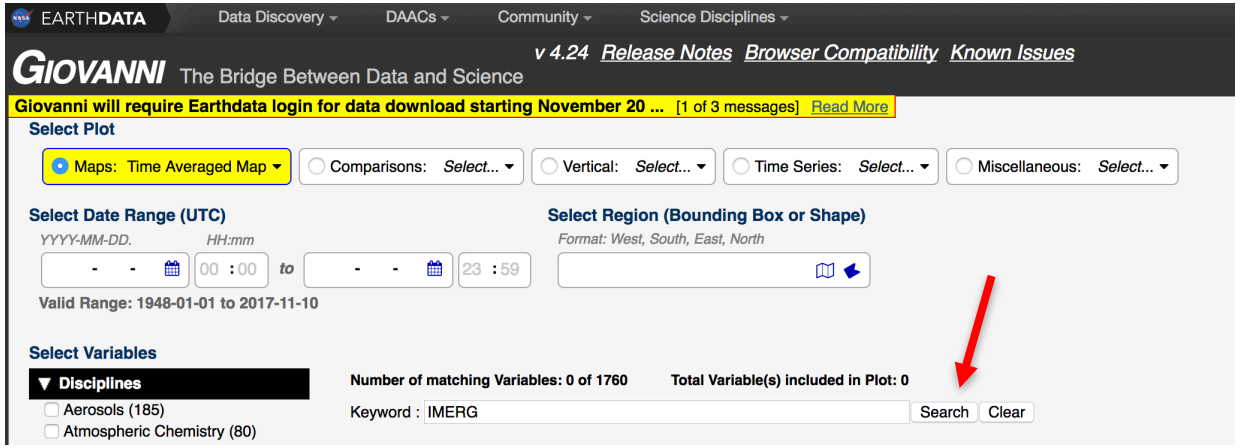
Subset Data and Make Monthly Precipitation Time Series

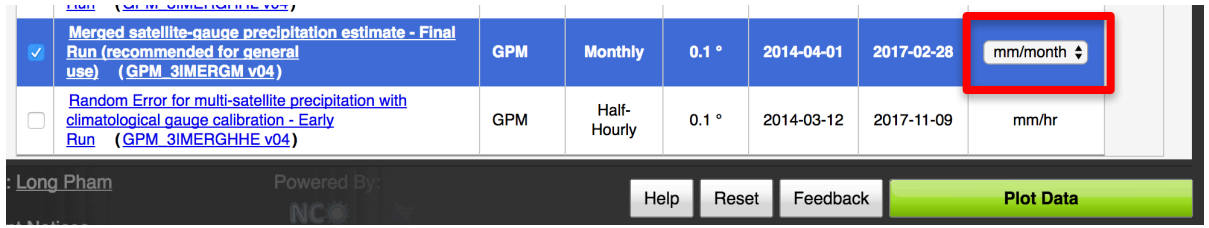
Subset Data and Make Monthly Precipitation Time Series

1. Go to Giovanni: http://giovanni.gsfc.nasa.gov/giovanni
2. On the Giovanni page you will see the following options:
   - **Select Plot:** allows selection of analysis options
   - **Select Data Range:** allows selection of a time period
   - **Select Region (Bounding Box or Shapefile):** allows selection of a geographic region by latitude-longitude, map, or shapefile
   - **Keyword:** allows search of data parameters by keyword
   - **Plot Data:** (located on the bottom right of the page) begins the action to make a desired plot

Subset Data and Make Monthly Precipitation Time Series

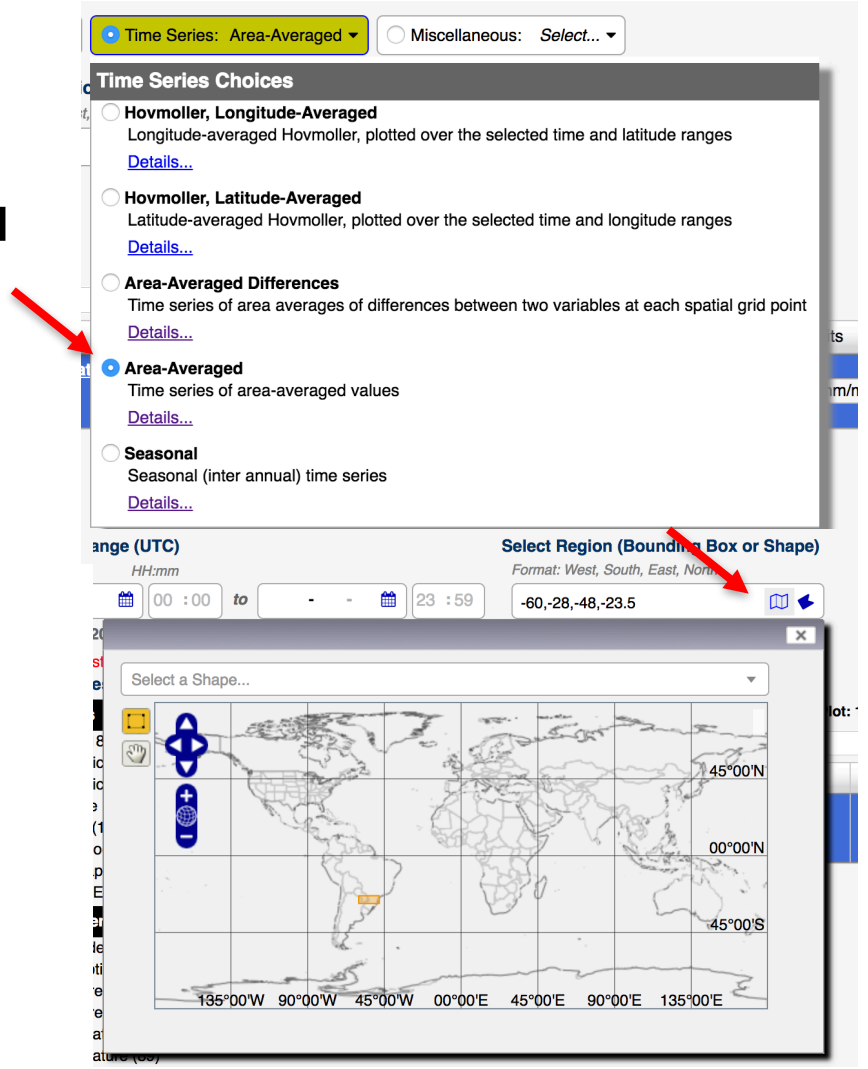
3. Enter the following options:
   - Next to **Keyword**
     - Enter IMERG. Click **Search**
     - Select **Merged satellite-gauge precipitation estimate – Final Run (recommended for general use) (GPM_3IMERGM v04)**
     - Set units to be mm/month





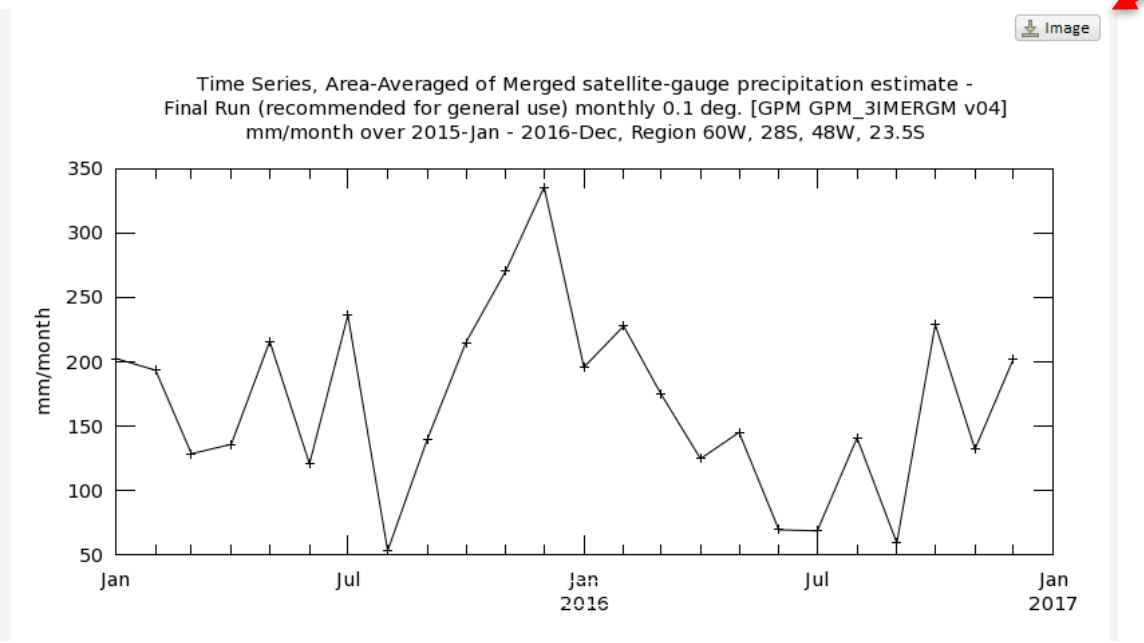
Subset Data and Make Monthly Precipitation Time Series

- Under Select Plot
  - The default selection is **Maps: Time Averaged Map**. Select **Time Series**, and then select **Area Averaged** from the drop-down menu
- Under Select Region (Bounding Box or Shape)
  - Enter the longitude-latitude around Parana: -60.0, -28.0, -48.0, -23.5
  - Note: west longitudes and south latitudes are negative, whereas east longitudes and north latitudes are positive
  - Click on the map icon to see the region



Subset Data and Make Monthly Precipitation Time Series

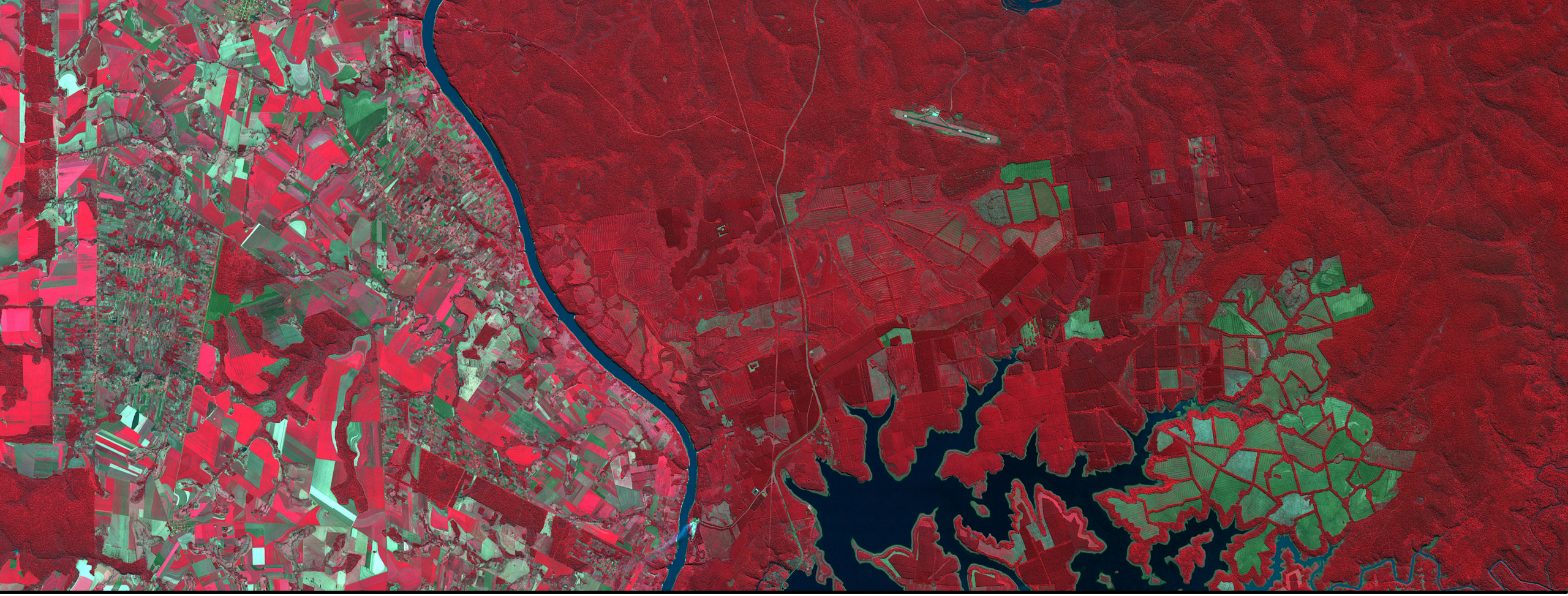
- Under Select Date Range (UTC)
  - In the YYY-MM windows, enter 2015 - 01 for start and 2016 - 12 for the end date
- Click on **Plot Data** (on the bottom right of the screen)
- You will get the following time series plot



Discussion Questions

1. Which month/year had the maximum rainfall over Parana? Note the magnitude of the rainfall (with units) for this month.

2. Is the month of maximum rainfall the same in both 2015 and 2016? How much does the maximum rain magnitude differ from 2015 to 2016?



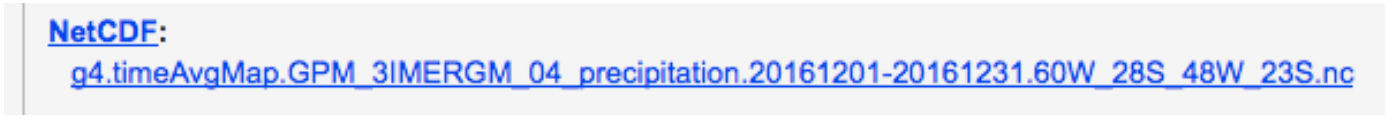
Make and Download Monthly Precipitation Maps

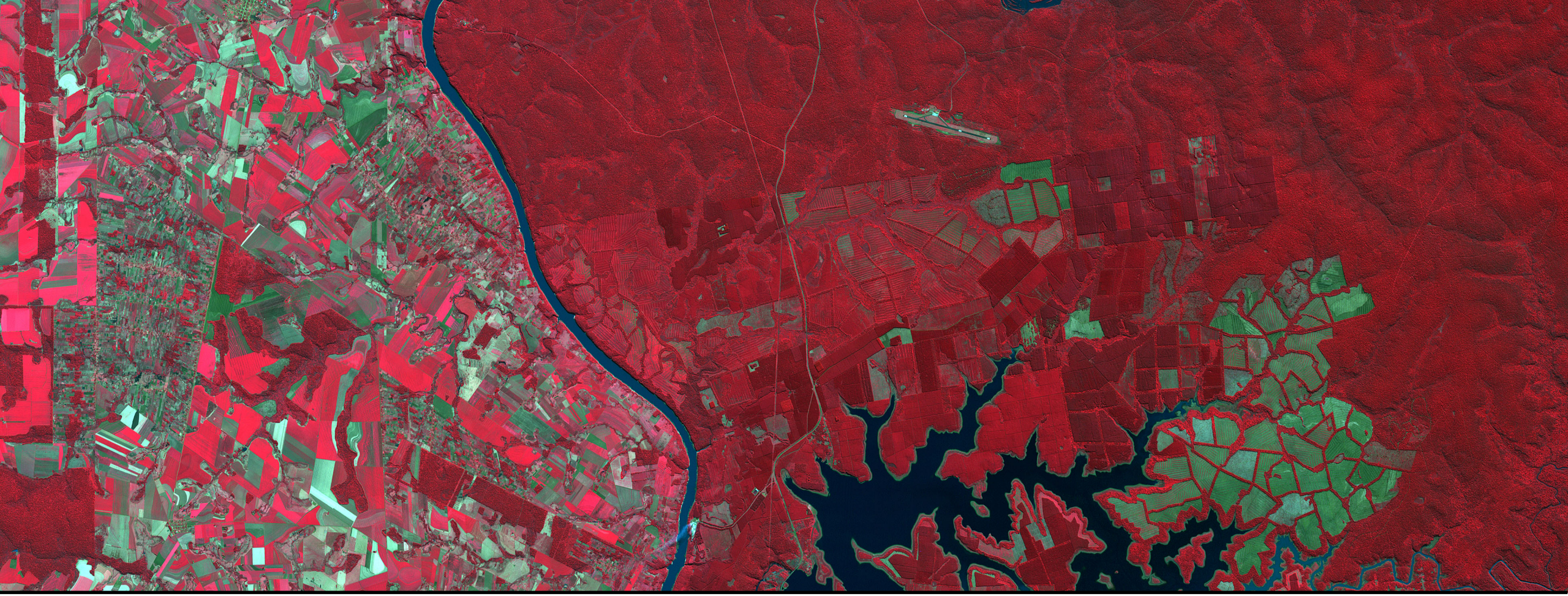
Make and Download Monthly Precipitation Maps

1. Click on **Back to Data Selection** on the lower right-hand side of the page
2. Enter the following options:
   - Under **Select Plot**, change to **Maps: Monthly and Seasonal**
   - Under **Select Seasonal Dates**, enter December and 2015 to 2015 (just the one month)
   - Click on **Plot Data** (on the bottom right)
   - You will get a map of monthly precipitation
   - Click on the **Downloads** link on the left, and you will see multiple file options. Choose the NetCDF file by clicking on the link to save the file to your computer.
     - Suggestion: Create a folder named 'Parana-Data' and save the December 2015 monthly files in the folder

Make and Download Monthly Precipitation Maps

- At the bottom right of the screen, click on **Back to Data Selection**
- Repeat **Select Data Range** for December 2016
- Click on the **Downloads** link on the left, click on the NetCDF file to save it on your computer in the same folder as the December 2015:
  - Suggestion: Rename the NetCDF file to avoid long Giovanni file name. For example: IMERG_Rain-Dec2015.nc & IMERG_Rain-2016.nc





Precipitation Analysis in QGIS

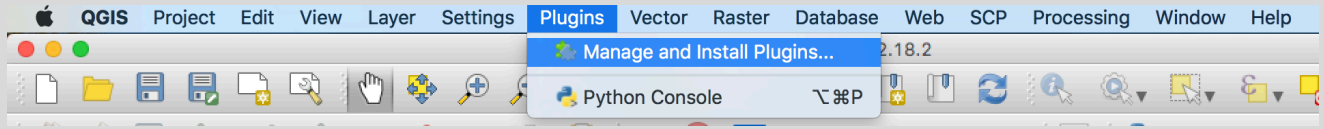
Precipitation Analysis in QGIS

- Note: For the precipitation data you will need the latest version of QGIS (Preferably 2.18) to work with the NetCDF files. **It is always a good idea to save your QGIS project often so that your work is not lost**.

1. Open QGIS and start a new project
2. On the top menu bar, click on **Web** to check if you have **OpenLayers Plugin**

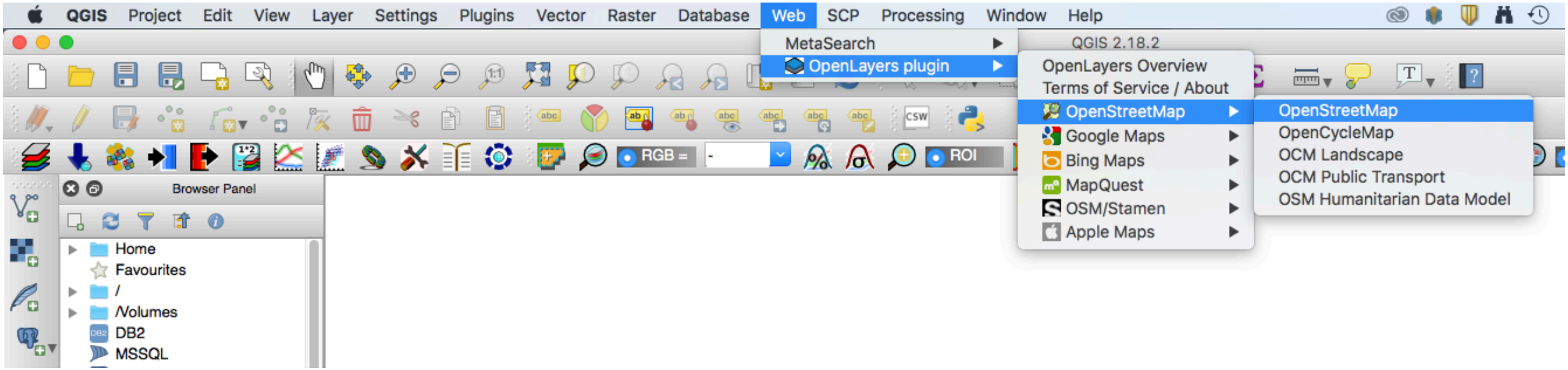
If you do not have the OpenLayers Plugin

- Select **Plugins** from the top menu, and choose **Manage and Install Plugins**
- You will get a window with options for Plugins
- Enter OpenLayers in the search window
- Clicking on the **OpenLayers Plugin** and press **Install** in the bottom right



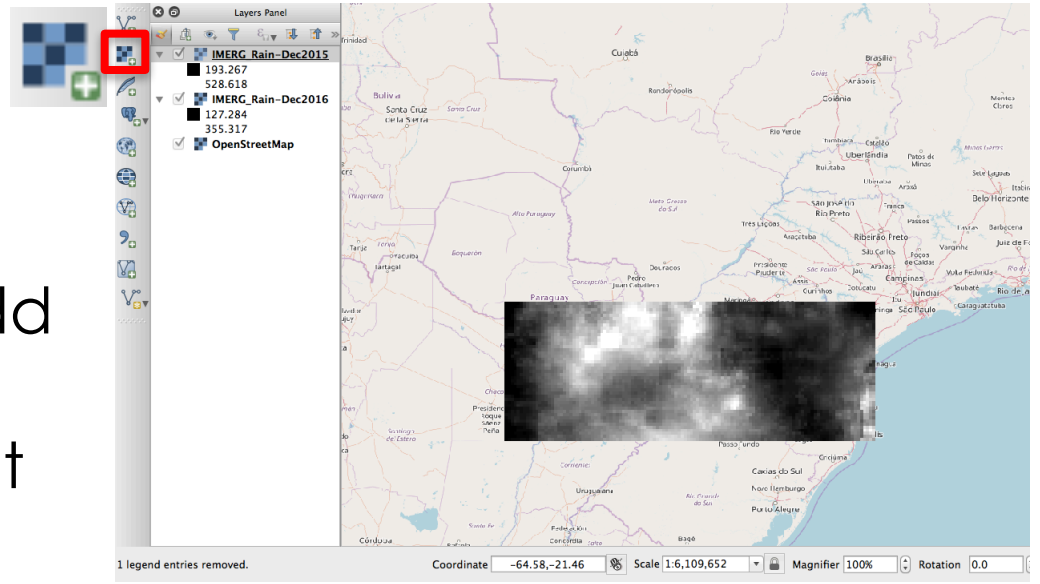
Precipitation Analysis in QGIS

3. From the top menu bar, click on **Web**, select **Open Layer Plugin** and select a background map
4. This exercise uses the background map **OpenStreetMap**



Convert NetCDF IMERG Data to GeoTiff

1. In your QGIS map, click on the **Add Raster** function on the left
2. Navigate to your saved IMERG Monthly Precipitation Files and click on **Open** to add the monthly data files for December 2015 and December 2016. You can do this all at once by highlighting both files.
   - A **Coordinate Reference System Selector** box may pop up. Select WGS84, EPSG 4326
   - From the top Menu Bar, you can zoom in and out on the layer



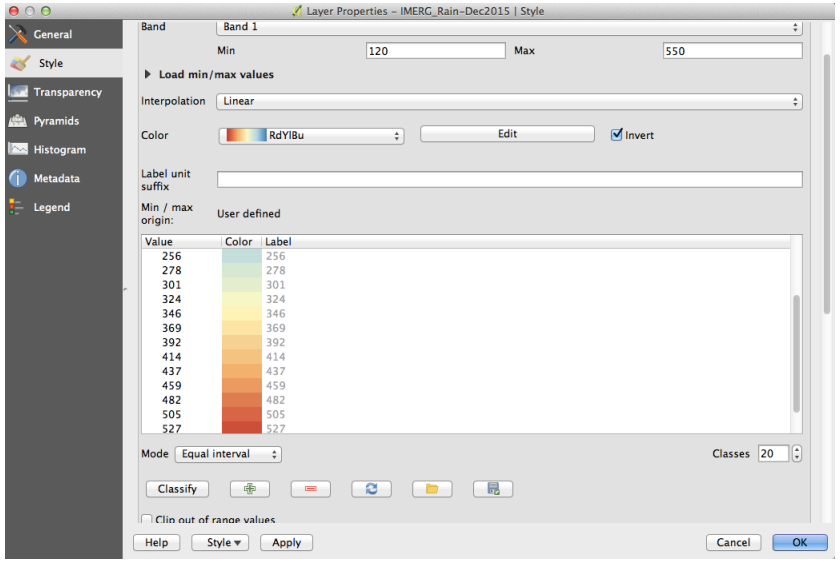
These NetCDF images have to be converted to GeoTIFF images for you to perform raster calculations on the data.

Convert NetCDF IMERG Data to GeoTiff

3. Right-Click (or Control-Click on Mac) on the raster layer IMERG_Rain-Dec2015
4. From the drop-down menu select **Save As** – this will open a window
   - Note that **Format** in the window is **Gtiff**
   - Make sure the **Add save file to map** option is checked.
   - Click on **Browse** and enter the folder name where all the data are and enter a file name (Suggestion: IMERG_Rain-Dec2015) and click on **Save**
   - You will see the GeoTiff layer displayed on the map and the file will be saved to the data folder
5. Repeat steps 3-4 to save the 2016 rain layer as a GeoTIFF
6. Now you can remove the NetCDF raster layers by right-clicking on each layer and choosing **Remove**

Convert NetCDF IMERG Data to GeoTiff

7. Right click on the layer file for December 2015 and go to **Properties** > **Style**
   - Select the **Render Type** as **Singleband Pseudocolor**
   - Next to **Color**, make sure the Red-Yellow-Blue (RdYlBu) color palette is selected
   - Select **Invert** so that low rain values are shown in blue and high in red
   - Select **Min** value to 120 mm/month and **Max** value to 550 mm/month
   - Below the color display, change the **Mode** to **Equal Interval** and **Classes** to 20. Click **Classify**. Click **Apply**



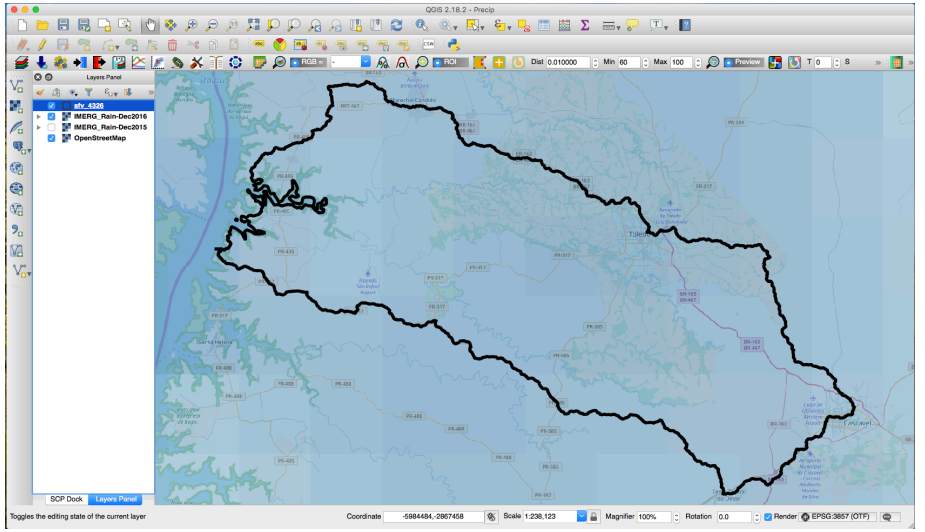
Convert NetCDF IMERG Data to GeoTiff

- Without closing the **Properties** window, move it over to take a look at the image. It should have the color designations you just selected.
- Click **OK** to close the Change Color box

8. Change the December 2016 layer map to have the same color scheme by following step 7
9. Make the precipitation layers for 2015 and 2016 semi-transparent to see the map underneath
   - Right click on the layer file and go to **Properties** > **Transparency**
   - Set the Transparency level to 50%
   - Under **No data value** set **Additional no data value** to 0
   - Click on **Apply** and then **OK**

Interpolate and Clip the Precipitation Data to SFV Watershed

1. Click on the menu on the left bar and click on **Add Vector**  to add the SFV shapefile sfv_4326.shp.
2. We'll make the shapefile layer transparent with only the boundary outlined on the map. Right click on the layer file and go to **Properties** > **Style**



   - Click on the down arrow in the **Fill** window and select **Transparent fill**
   - Click on the down arrow in the Outline window and choose a color of the shapefile boundary (Black color is chosen in this case)
   - Choose **outline width** to be 2.0
   - Click **OK**

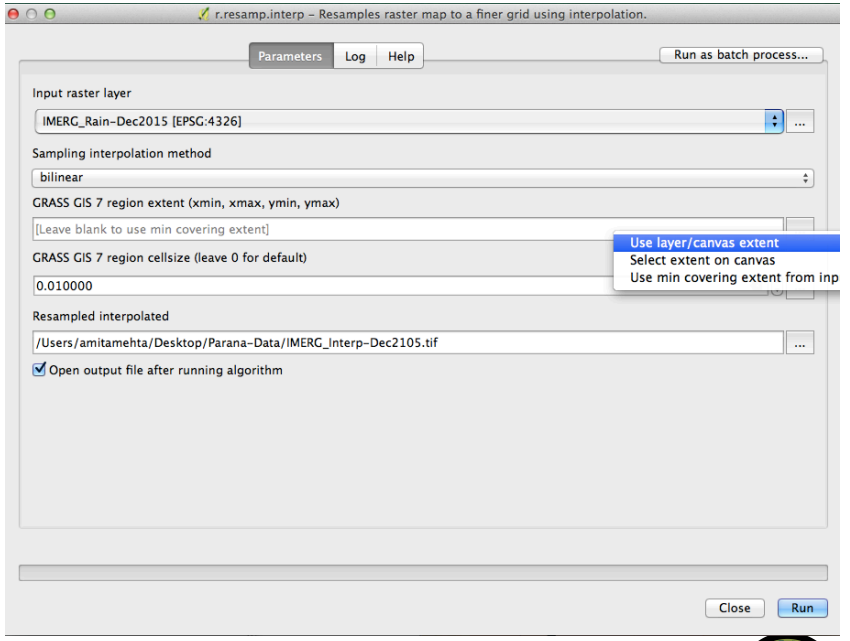
Interpolate and Clip the Precipitation Data to SFV Watershed

3. In the top menu, select **Processing** > **Toolbox**. A search window will appear to the right of the map. Enter interp.
   - You should see r.resamp.interp from the list
4. Double click on **r.resamp.interp –** this will open a window
5. In the **Input Raster Layer** window use the dropdown menu arrow to select IMERG_Rain-Dec2015 raster
   - In the **Sampling interpolation method** window, chose bilinear
   - In the **GRASS GIS 7 region extern (xmin,xmax,ymin,ymax)** window choose **Layer/canvas extent** from the dropdown menu
   - In the **GRASS GIS 7 region cellsize (leave 0 for default)** window enter the factor 0.01 [Note: the resolution of the IMERG data is 0.1 degree, we are interpolating to 1 km by specifying 0.01 cell size]

Interpolate and Clip the Precipitation Data to SFV Watershed

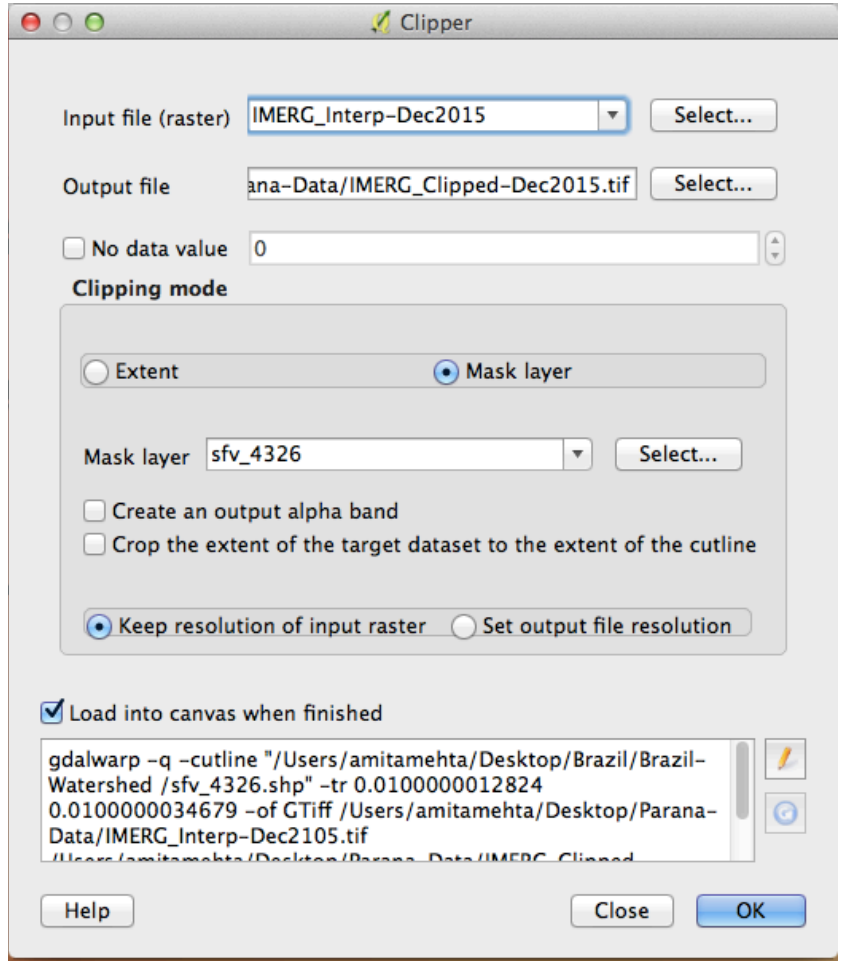
- In the **Resampled Interpolated** window specify the folder and filename where the interpolated data will be saved.
- Make sure that **Open output file after running algorithm** is selected
- Click on **Run** at the bottom right
- You will get a resampled interpolated data layer on the map (in grey colors)
- By right clicking on the resampled layer > **Rename** layer (suggest IMERG_Interp-Dec2015)

6. Repeat step 4 and interpolate the 2016 rain data



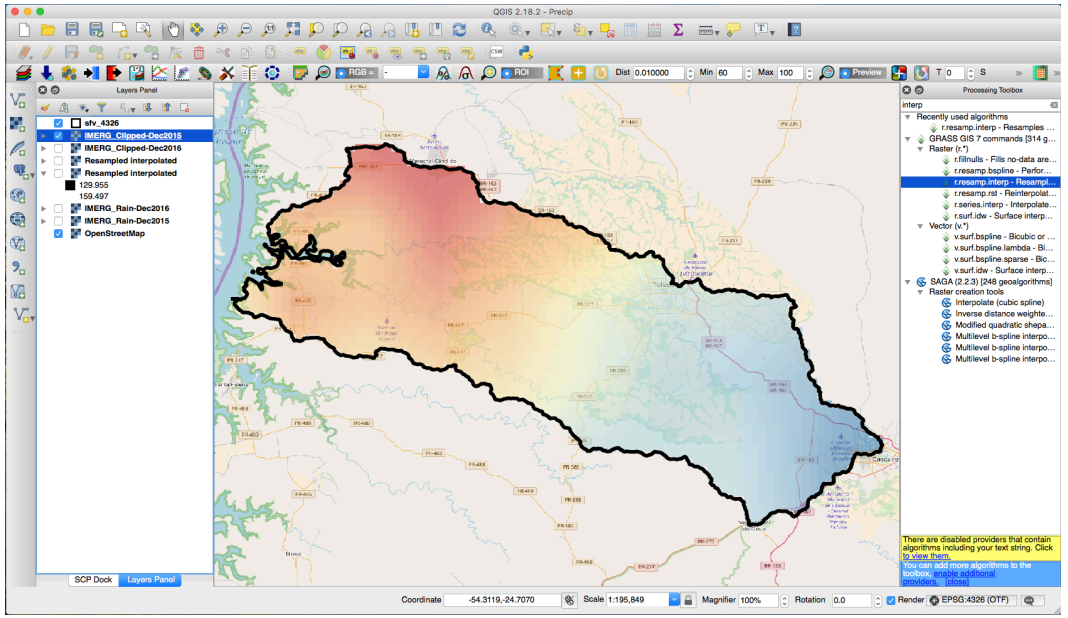
Interpolate and Clip the Precipitation Data to SFV Watershed

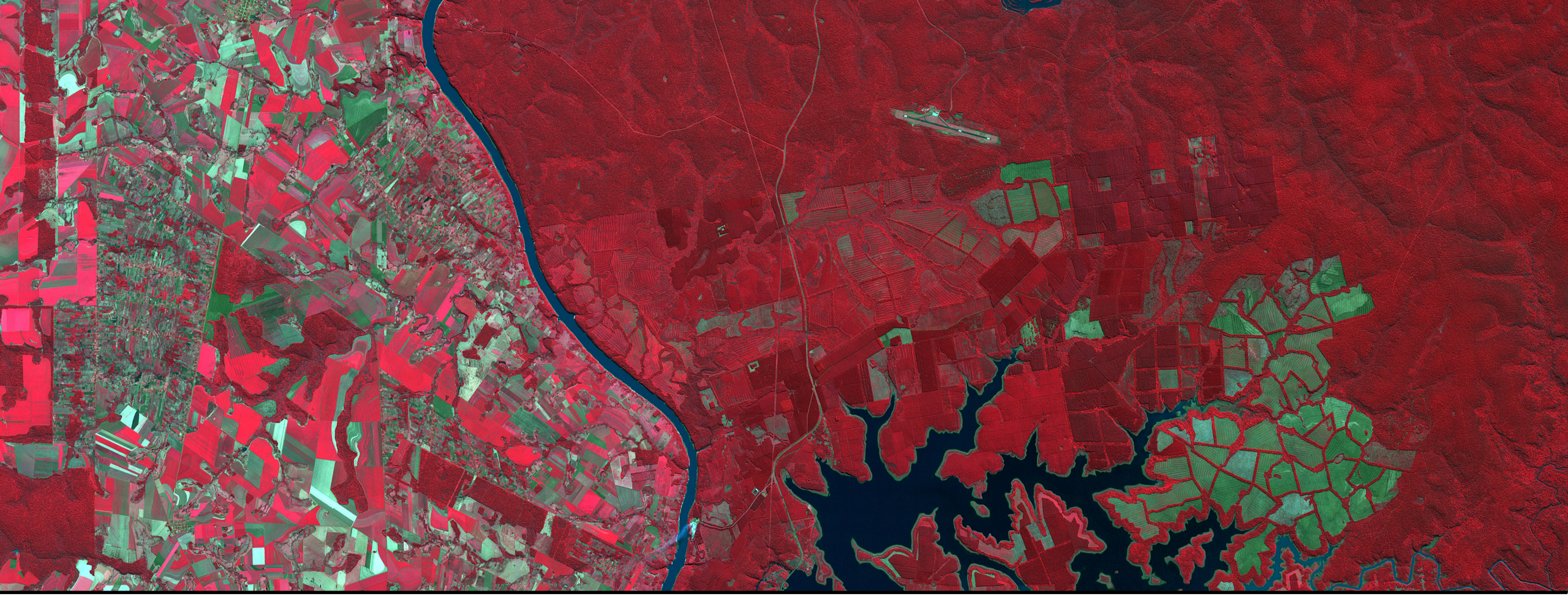
7. Now Clip the interpolated rain layers to the SFV watershed shapefile
   - On the top bar go to **Raster** > **Extraction** > **Clipper** to open the Clipper options window
   - In the Input File (raster) window select interpolated layer IMERG_Interp-Dec2015
   - In the Output file window select output folder and enter file name (suggest IMERG_Clipped-Dec2015).
   - Check the **Mask Layer** and in the **Mask Layer** window select the shapefile name sfv_4326.
   - Click **OK** on at the bottom right. You will see the data clipped by the shapefile boundary



Interpolate and Clip the Precipitation Data to SFV Watershed

8. Repeat the above step for 2016 interpolated rain layer
9. Follow steps 7-9 of **Convert NetCDF IMERG Data to GeeoTIFF** to add colors to the clipped rain layers for 2015 and 2016. You can choose the appropriate minimum and maximum values and intervals/classes for the color table.
   - Note in the following example 10 classes are used. The rain range for 2015 is set to 380 to 550 mm/month while that for 2016 is set to 120 to 160 mm/month





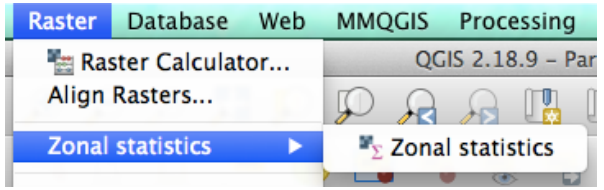
Precipitation Analysis over SFV Watershed

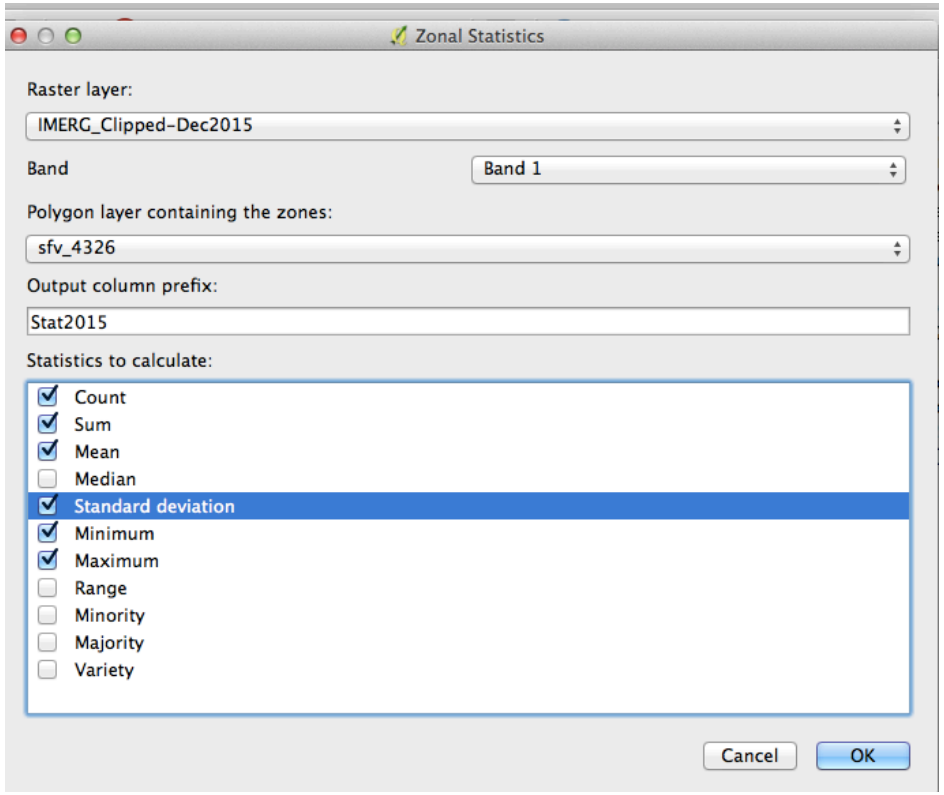
Examine Histograms for Rainfall During December 2015 & 2016

1. Right Click on IMERG_Clipped-Dec2015 and go to **Properties** > **Histogram**
2. Click **Compute Histogram**
3. You will get a histogram, minimum and maximum rain values for this layer. Note down the **Min** and **Max** values.
4. Repeat the steps 1 and 2 for IMERG_Clipped_Dec2016.
5. Compare the two histograms, looking at minimum and maximum values for the two maps

Examine Mean and Standard Deviation of Rain Data Over SFV

1. On the top bar select **Raster** > **Zonal Statistics** or search for **Zonal Statics** in the **Processing Toolbox**
2. You will get the Zonal Statistics option window
3. In the **Raster Layer** window select IMERG_Clipped-Dec2015
4. In the **Polygon layer containing zone** window make sure the sfv_4326 shapefile is selected
5. In the **Output column prefix** enter **Stat2015** (or any name that you want to use to identify statistics for this layer)



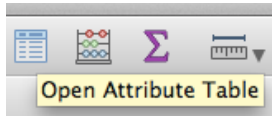


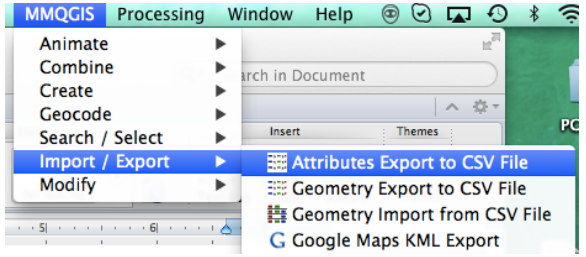
Examine Mean and Standard Deviation of Rain Data Over SFV

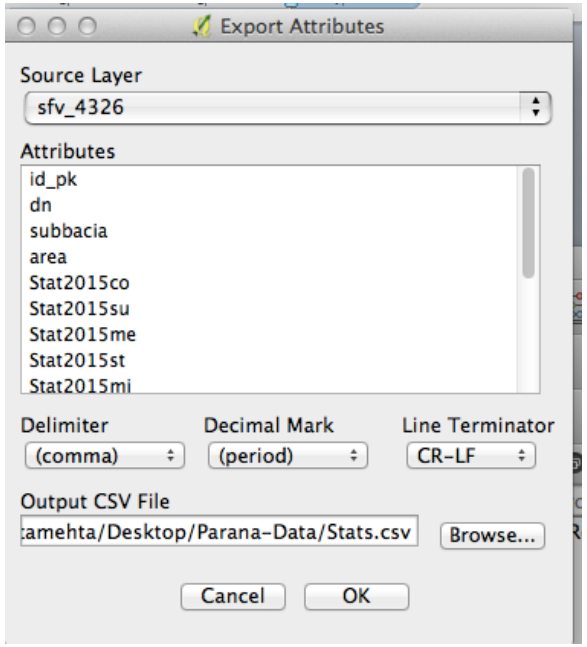
6. In the **Statistics to calculate** window select **Count, Sum, Mean, Standard deviation, Minimum, Maximum**
7. Click **OK** on the bottom right
8. Repeat the above steps for IMERG_Cliped-Dec2016. Remember to change the prefix (suggest Stats2016)

Examine Mean and Standard Deviation of Rain Data Over SFV

9. The statistics will be available in the **Attribute Table** from the top bar or right click on the shapefile under the layers panel
   - Click on the Attribute Table and examine the numbers.
   - You can copy the statistics Mean, Standard deviation, Minimum and Maximum for 2015 and 2016 layers. OR save the Attribute Table as a CSV file by using a plugin MMQGIS. If you do not have this plugin then follow the procedure you used to download and install OpenLayers plugin (Part 2, Steps 1-3), but use MMQGIS instead of OpenLayers.
10. Use **MMQGIS** > **Import/Export** > **Attributes Export to CSV File**







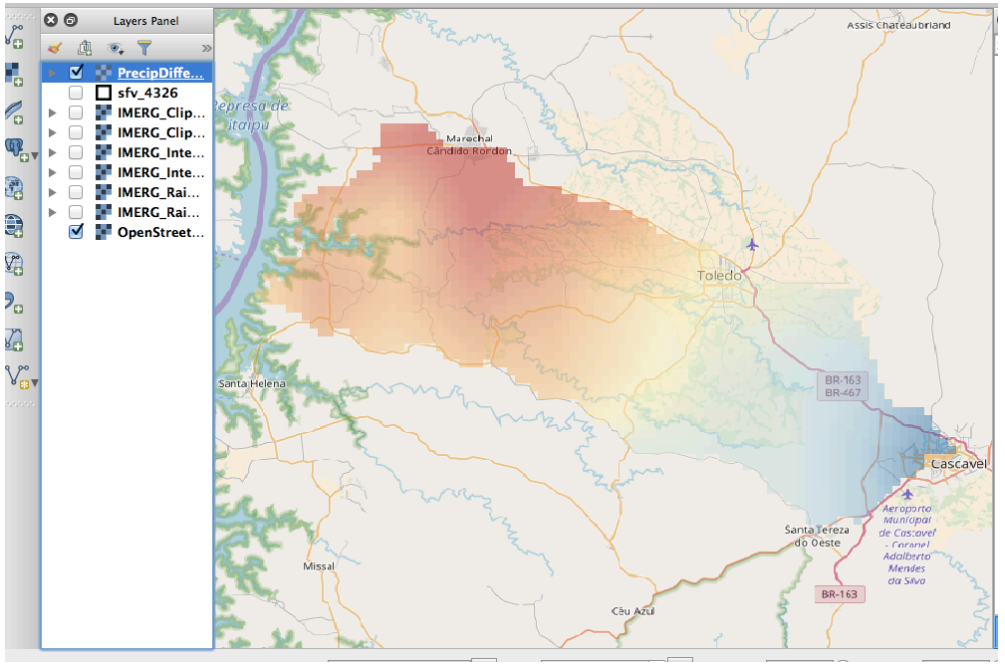
Examine Inter-Annual Difference in Precipitation

You will be calculating difference between precipitation in December 2015 and December 2016

1. Select **Raster** > **Raster Calculator**
2. From the Raster bands double click on **IMERG_Clipped-Dec2015@1** layer.
3. The layer will appear in the **Raster Calculator Expression** Window
4. Now select minus sign (-) from the **Operators**
5. From the Raster bands double click on **IMERG_Clipped-Dec2016@1** layer. The layer will appear in the **Raster Calculator Expression** Window

Examine Inter-Annual Difference in Precipitation

6. In the **Raster Layer** > **Output Layer** enter the folder/file name where the difference layer will be saved (Suggestion: PrecipDifference_Dec15&16)
7. Make sure that **Add result to project** is checked
8. Click **OK** to get the Difference map.
9. Make the difference layer transparent by right clicking on the layer's **Properties** > **Transparency** and set the level to 50% so that you can see the map. Toggle the map layers on and off to see the spatial distribution of rainfall and its interannual difference



Discussion Questions

1. Over the SFV watershed, which year had more precipitation in December?

2. Based on the zonal statics, what are the means and standard deviations for the two years? What were the minimum and maximum precipitation values for the two years?

3. Examine the rainfall frequency distribution shown in the histograms of the two months of December.

4. From the statistics and the precipitation difference, which December had less water availability? Over the SFV watershed, what was the mean deficiency of precipitation (in mm/month)? Which areas of the watershed experienced the largest inter annual difference in precipitation?

Discussion Questions

5. Based on the precipitation difference map (between December 2015 and 2016), which areas of the SFV watershed would experience the greatest changes in soil moisture and vegetation in January and February 2017, compared to the same months in 2016?

6. If you do not interpolate IMERG precipitation data would your results be different? Why?

7. Based on the procedure used in this exercise, can you outline the steps (including data and tools) you would take to monitor weekly precipitation availability and pattern in near real-time?